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- 64 -

Related Pending Application

Related Case Serial No: 10/060247

Related Case Filing Date: 02-01 - 02

WHAT IS CLAIMED IS:

- 1. A magnetoresistive device, comprising:
- a magnetization pinned layer of which magnetization direction is substantially pinned to one direction;
- a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;
- a nonmagnetic intermediate layer formed between the magnetization pinned layer and the magnetization free layer; and

electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

wherein at least one of the magnetization pinned layer and the magnetization free layer is substantially formed of a binary alloy or a ternary alloy represented by general formula (1) or (2) given below:

 $T1_aT2_b$ (1)

 $Fe_{C}Co_{d}Ni_{e}$ (2)

where T1 and T2 are different from each other and selected from the group consisting of Fe, Co and Ni,

25 25 at% \leq a \leq 75 at%, 25 at% \leq b \leq 75 at%, and a + b = 100; and

 $0 < c \le 75 \text{ at}$ %, $0 < d \le 75 \text{ at}$ %, $0 < e \le 63 \text{ at}$ %,

and c + d + e = 100.

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2. A magnetoresistive device, comprising:

a magnetization pinned layer of which magnetization direction is substantially pinned to one direction;

a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;

a nonmagnetic intermediate layer formed between the magnetization pinned layer and the magnetization free layer; and

electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

wherein at least one of the magnetization pinned layer and the magnetization free layer is formed of an alloy represented by general formula (3) or (4) given below:

$$(Tl_a/100^{T2}b/100)_{100-x}Ml_x$$
 (3)

where T1, T2 and T3 are different from each other and selected from the group consisting of Fe, Co and

Ni; M1 is at least one element selected from the group consisting of Cr, V, Ta, Nb, Sc, Ti, Mn, Cu, Zn, Ga,

Ge, Zr, Hf, Y, Tc, Re, Ru, Rh, Ir, Pd, Pt, Ag, Au, B,

Al, In, C, Si, Sn, Ca, Sr, Ba, O, N and F;

25 at% \leq a \leq 75 at%, 25 at% \leq b \leq 75 at%, and

a + b = 100;

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5 at% \leq c \leq 90 at%, 5 at% \leq d \leq 90 at%,

5 at% \leq e \leq 90 at%, and c + d + e = 100; and

0.1 at% $\le x \le 30$ at%.

- 3. A magnetoresistive device, comprising:
- a magnetization pinned layer of which magnetization direction is substantially pinned to one direction;

a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;

a nonmagnetic intermediate layer formed between

the magnetization pinned layer and the magnetization
free layer; and

electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

wherein at least one of the magnetization pinned layer and the magnetization free layer is substantially formed of an alloy represented by general formula (5) given below:

 $Fe_{100-a}T1_a$ (5)

where T1 is at least one element selected from the

group consisting of Co, Cr, V, Ni, Rh, Ti, Mo, W, Nb, Ta, Pd, Pt, Zr and Hf; and

0 at% \leq a < 70 atomic %;

and wherein the alloy has a body-centered cubic crystal structure.

- 4. A magnetoresistive device, comprising a magnetization pinned layer of which magnetization direction is substantially pinned to one direction;
- a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;

a nonmagnetic intermediate layer formed between the magnetization pinned layer and the magnetization free layer; and

electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

wherein at least one of the magnetization pinned layer and the magnetization free layer is substantially formed of an alloy represented by general formula (6) given below:

 $Fe_{100-a}T_a$ (6)

where

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0 at% \leq a \leq 80 at%, in the case where T1 is Co;

- 0 at% \leq a \leq 80 at%, in the case where T1 is Cr;
- 0 at% \leq a \leq 70 at%, in the case where Tl is V;
- 0 at% \leq a \leq 20 at%, in the case where T1 is Ni;
- 0 at% \leq a \leq 55 at%, in the case where T1 is Rh;
- 5 and

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- 0 at% ≤ a ≤ 51 at%, in the case where T1 is Ti; and wherein the alloy has a body-centered cubic crystal structure.
 - 5. A magnetoresistive device, comprising:
- a magnetization pinned layer of which magnetization direction is substantially pinned to one direction;
 - a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;
 - a nonmagnetic intermediate layer formed between the magnetization pinned layer and the magnetization free layer; and
- electrodes allowing a sense current to flow in

 a direction substantially perpendicular to the plane of
 the stack including the magnetization pinned layer, the
 nonmagnetic intermediate layer and the magnetization
 free layer,
- wherein at least one of the magnetization pinned

 layer and the magnetization free layer is formed of a

 ternary alloy selected from the group consisting of an

 Fe-Co-Ni alloy, a Co-Mn-Fe alloy and an Fe-Cr-Co alloy;

and wherein the ternary alloy has a body-centered cubic crystal structure.

- 6. A magnetoresistive device, comprising:
- a magnetization pinned layer of which
- 5 magnetization direction is substantially pinned to one direction;

a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;

a nonmagnetic intermediate layer formed between the magnetization pinned layer and the magnetization free layer; and

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electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

wherein at least one of the magnetization pinned layer and the magnetization free layer is substantially formed of an alloy represented by any of general formulas (7) to (10) given below:

$$(Fe (100-a)/100^{T1}a/100)_{100-x}M_{x}$$
 (7)
 $(Fe-Co-Ni)_{100-x}M_{x}$ (8)
 $(Co-Mn-Fe)_{100-x}M_{x}$ (9)
 $(Fe-Cr-Co)_{100-x}M_{x}$ (10)

where Tl is at least one element selected from the group consisting of Co, Cr, V, Ni, Rh, Ti, Mo, W, Nb,

Ta, Pd, Pt, Zr and Hf, and 0 at% ≦ a < 70 atomic %;
 the Fe-Co-Ni alloy is in a composition region
forming a body-centered cubic crystal;</pre>

the Co-Mn-Fe alloy is in a composition region forming a body-centered cubic crystal structure;

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the Fe-Cr-Co alloy is in a composition region forming a body-centered cubic crystal structure;

- 0.1 at% \leq x \leq 20 at%, in the case where M is at least one element selected from the group consisting of Mn, Cu, Re, Ru, Pd, Pt, Ag, Au and Al; and
- 0.1 at% \leq x \leq 10 at%, in the case where M is at least one element selected from the group consisting of Sc, Zn, Ga, Ge, Zr, Hf, Y, Tc, B, In, C, Si, Sn, Ca, Sr, Ba, O, F and N;
- and wherein the alloy has a body-centered cubic crystal structure.
 - 7. A magnetoresistive device, comprising:
 a magnetization pinned layer of which
 magnetization direction is substantially pinned to one
 direction;
 - a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;
- a nonmagnetic intermediate layer formed between

 the magnetization pinned layer and the magnetization
 free layer; and

electrodes allowing a sense current to flow in

a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

wherein at least one of the magnetization pinned layer and the magnetization free layer is substantially formed of an alloy represented by general formula (11) given below:

 $(Fe(100-a)/100Tl_a/100)100-xM_x$ (11)

10 where

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0 at% \leq a \leq 80 at%, in the case where T1 is Co;

0 at% \leq a \leq 80 at%, in the case where T1 is Cr;

0 at% \leq a \leq 70 at%, in the case where T1 is V;

0 at% \leq a \leq 10 at%, in the case where T1 is Ni;

0 at% \leq a \leq 55 at%, in the case where T1 is Rh;

0 at% \leq a \leq 51 at%, in the case where T1 is Ti;

0.1 at% \leq x \leq 20 at%, in the case where M is at least one element selected from the group consisting of Mn, Cu, Re, Ru, Pd, Pt, Ag, Au and Al; and

0.1 at% \leq x \leq 10 at%, in the case where M is at least one element selected from the group consisting of Sc, Zn, Ga, Ge, Zr, Hf, Y, Tc, B, In, C, Si, Sn, Ca, Sr, Ba, O, F and N;

and wherein the alloy has a body-centered cubic crystal structure.

8. A magnetoresistive device, comprising:
a magnetization pinned layer of which

magnetization direction is substantially pinned to one direction;

a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;

a nonmagnetic intermediate layer formed between the magnetization pinned layer and the magnetization free layer; and

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electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

wherein at least one of the magnetization pinned layer and the magnetization free layer is substantially formed of an alloy represented by general formula (12) given below:

$$(Fe(100-a)/100^{T1}a/100)100-x^{M}x$$
 (12)

where T1 is at least one element selected from the group consisting of Co and Ni, and 0 at% \leq a \leq 50 at%; and

M is at least one element selected from the group consisting of Sc, Ti, Mn, Cu, Zn, Ga, Ge, Zr, Hf, Y, Tc, Re, Ru, Rh, Ir, Pd, Pt, Ag, Au, B, Al, In, C, Si, Sn, Ca, Sr, Ba, O, N and F, and 0.1 at% $\leq x \leq 30$ at%.

- 9. A magnetoresistive device, comprising:
- a magnetization pinned layer of which

magnetization direction is substantially pinned to one direction;

a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;

a nonmagnetic intermediate layer formed between the magnetization pinned layer and the magnetization free layer; and

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electrodes allowing a sense current to flow in

a direction substantially perpendicular to the plane of
the stack including the magnetization pinned layer, the
nonmagnetic intermediate layer and the magnetization
free layer,

wherein at least one of the magnetization pinned

layer and the magnetization free layer is substantially
formed of an alloy represented by general formula (13)
given below:

$$(Fe(100-a)/100^{T_1}a/100)100-x^{M_X}$$
 (13)

where T1 is at least one element selected from the group consisting of Co and Ni, and 0 at% \leq a \leq 50 at%; and

M is at least one element selected from the group consisting of Cu, Zn and Ga, and 0.1 at% \leq x \leq 30 at%.

10. A magnetoresistive device, comprising:

a magnetization pinned layer of which
magnetization direction is substantially pinned to one direction;

a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;

a nonmagnetic intermediate layer formed between the magnetization pinned layer and the magnetization free layer; and

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electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

wherein at least one of the magnetization pinned layer and the magnetization free layer is substantially formed of an alloy represented by general formula (14) given below:

 $Fe_{100-x}M_x$ (14)

where M is at least one element selected from the group consisting of Co and Ni, and 0.1 at% \leq x \leq 5 at%.

- 20 11. A magnetoresistive device, comprising:
 - a magnetization pinned layer of which magnetization direction is substantially pinned to one direction;
- a magnetization free layer of which magnetization

 25 direction is changed in accordance with an external

 magnetic field;
 - a nonmagnetic intermediate layer formed between

the magnetization pinned layer and the magnetization free layer; and

electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

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wherein at least one of the magnetization pinned layer and the magnetization free layer is substantially formed of an alloy represented by general formula (15) given below:

$$(Co(100-a)/100T1_a/100)_{100-x}M_x$$
 (15)

where T1 is at least one element selected from the group consisting of Fe and Ni, and 0 at% \leq a \leq 50 at%; and

M is at least one element selected from the group consisting of Cr, V, Ta, Nb, Sc, Ti, Mn, Cu, Zn, Ga, Ge, Zr, Hf, Y, Tc, Re, Ru, Rh, Ir, Pd, Pt, Ag, Au, B, Al, In, C, Si, Sn, Ca, Sr, Ba, O, N and F, and 0.1 at% $\leq x \leq 30$ at%.

12. A magnetoresistive device, comprising:

a magnetization pinned layer of which magnetization direction is substantially pinned to one direction;

a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;

a nonmagnetic intermediate layer formed between the magnetization pinned layer and the magnetization free layer; and

electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

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wherein at least one of the magnetization pinned

layer and the magnetization free layer is substantially
formed of an alloy represented by general formula (16)
given below:

 $(Co(100-a)/100^{T1}a/100)100-x^{M}x$ (16)

where T1 is at least one element selected from the group consisting of Fe and Ni, and 0 at% \leq a \leq 50 at%; and

M is at least one element selected from the group consisting of Sc, Ti, Mn, Cu and Hf, and 0.1 at% \leq x \leq 30 at%.

20 13. A magnetoresistive device, comprising:

a magnetization pinned layer of which magnetization direction is substantially pinned to one direction;

a magnetization free layer of which magnetization

direction is changed in accordance with an external

magnetic field;

a nonmagnetic intermediate layer formed between

the magnetization pinned layer and the magnetization free layer; and

electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

wherein at least one of the magnetization pinned layer and the magnetization free layer is substantially formed of an alloy represented by general formula (17) given below:

 $Co_{100-x}M_x$ (17)

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where M is at least one element selected from the group consisting of Fe and Ni, and 0.1 at% \leq x \leq 5 at%.

- 14. A magnetoresistive device, comprising:
- a magnetization pinned layer of which magnetization direction is substantially pinned to one direction:
- a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;
 - a nonmagnetic intermediate layer formed between the magnetization pinned layer and the magnetization free layer; and

electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of

the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

wherein at least one of the magnetization pinned layer and the magnetization free layer is substantially formed of an alloy represented by general formula (18) given below:

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 $(Ni (100-a)/100^{T1}a/100) 100-x^{M}x$ (18)

where T1 is at least one element selected from the group consisting of Co and Fe, and 0 at% \leq a \leq 50 at%; and

M is at least one element selected from the group consisting of Cr, V, Ta, Nb, Sc, Ti, Mn, Cu, Zn, Ga, Ge, Zr, Hf, Y, Tc, Re, Ru, Rh, Ir, Pd, Pt, Ag, Au, B, Al, In, C, Si, Sn, Ca, Sr, Ba, O, N and F, and 0.1 at% $\leq x \leq 30$ at%.

15. A magnetoresistive device, comprising:

a magnetization pinned layer of which magnetization direction is substantially pinned to one direction;

a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;

a nonmagnetic intermediate layer formed between

the magnetization pinned layer and the magnetization
free layer; and

electrodes allowing a sense current to flow in

a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

wherein at least one of the magnetization pinned layer and the magnetization free layer is substantially formed of an alloy represented by general formula (19) given below:

$$(Ni (100-a)/100^{T1}a/100) 100-x^{M}x$$
 (19)

where Tl is at least one element selected from the group consisting of Fe and Co, and 0 at% \leq a \leq 50 at%; and

M is at least one element selected from the group consisting of Sc, Ti, Mn, Zn, Ga, Ge, Zr and Hf, and 0.1 at% \leq x \leq 30 at%.

16. A magnetoresistive device, comprising:

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a magnetization pinned layer of which magnetization direction is substantially pinned to one direction;

a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;

a nonmagnetic intermediate layer formed between the magnetization pinned layer and the magnetization free layer; and

electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of

the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

wherein at least one of the magnetization pinned layer and the magnetization free layer is substantially formed of an alloy represented by general formula (20) given below:

 $Ni_{100-x}M_x \tag{20}$

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where M is at least one element selected from the group consisting of Fe and Co, and 0.1 at% $\leq x \leq$ 5 at%.

17. A magnetoresistive device, comprising:

a magnetization pinned layer of which magnetization direction is substantially pinned to one direction;

a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;

a nonmagnetic intermediate layer formed between
the magnetization pinned layer and the magnetization
free layer; and

electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

wherein at least one of the magnetization pinned

layer and the magnetization free layer is substantially formed of a binary alloy or a ternary alloy represented by general formula (21-a) or (21-b) given below:

 $(T1_aT2_b)_{100-x}M_x$ (21-a)

 $5 \qquad (Fe_CCo_dNi_e)_{100-x}M_x \qquad (21-b)$

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where T1 and T2 are different from each other and selected from the group consisting of Fe, Co and Ni, 25 at% \leq a \leq 75 at%, 25 at% \leq b \leq 75 at%, and a + b = 100;

10 $0 < c \le 75$ at%, $0 < d \le 75$ at%, $0 < e \le 63$ at%, and c + d + e = 100; and

M is at least one element selected from the group consisting of Cr, V, Ta, Nb, Sc, Ti, Mn, Cu, Zn, Ga, Ge, Zr, Hf, Y, Tc, Re, Ru, Rh, Ir, Pd, Pt, Ag, Au, B, Al, In, C, Si, Sn, Ca, Sr, Ba, O, N and F, and 0.1 at% $\leq x \leq 20$ at%.

18. A magnetoresistive device, comprising:

a magnetization pinned layer of which magnetization direction is substantially pinned to one direction;

a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;

a nonmagnetic intermediate layer formed between the magnetization pinned layer and the magnetization free layer; and

electrodes allowing a sense current to flow in

a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

wherein at least one of the magnetization pinned layer and the magnetization free layer has a laminate structure comprising alternately laminated layers of:

(i) at least one layer substantially formed of an alloy represented by general formula (22-a) or (22-b) given below:

 $T1_aT2_b \tag{22-a}$

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 $Fe_CCo_dNi_e$ (22-b)

where T1 and T2 are different from each other and selected from the group consisting of Fe, Co and Ni, 25 at% \leq a \leq 75 at%, 25 at% \leq b \leq 75 at%, and a + b = 100; and

 $0 < c \le 75$ at%, $0 < d \le 75$ at%, $0 < e \le 63$ at%, and c + d + e = 100; and

- (ii) at least one layer formed of at least one
 20 element selected from the group consisting of Cr, V,
 Ta, Nb, Sc, Ti, Mn, Cu, Zn, Ga, Ge, Zr, Hf, Y, Tc, Re,
 Ru, Rh, Ir, Pd, Pt, Ag, Au, B, Al, In, C, Si, Sn, Ca,
 Sr, Ba, O, N and F, and having a thickness falling
 within a range of between 0.03 nm and 1 nm.
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 19. A magnetoresistive device, comprising:

 a magnetization pinned layer of which magnetization direction is substantially pinned to one

direction;

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a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;

a nonmagnetic intermediate layer formed between the magnetization pinned layer and the magnetization free layer; and

electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

wherein at least one of the magnetization pinned layer and the magnetization free layer is substantially formed of an alloy represented by general formula (23) or (24) given below:

 $(Ni_a Fe_b Co_c)_{100-x} M_x \tag{23}$

 $(Ni_dFe_{100-d})_{100-x}M_x$ (24)

where $0 < a \le 75 \text{ at}\%$, $0 < b \le 75 \text{ at}\%$,

20 $0 < c \le 75 \text{ at%}, \text{ and a + b = 100};$

75 at% \leq d \leq 85 at%; and

M is at least one element selected from the group consisting of Cr, V, Ta, Nb, Sc, Ti, Mn, Cu, Zn, Ga, Ge, Zr, Hf, Y, Tc, Re, Ru, Rh, Ir, Pd, Pt, Ag, Au, B,

25 Al, In, C, Si, Sn, Ca, Sr, Ba, O, N and F, and 0.1 at% $\leq x \leq 20$ at%.

20. A magnetoresistive device, comprising:

a magnetization pinned layer of which magnetization direction is substantially pinned to one direction;

a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;

a nonmagnetic intermediate layer formed between the magnetization pinned layer and the magnetization free layer; and

electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

wherein at least one of the magnetization pinned layer and the magnetization free layer has a laminate structure comprising alternately laminated layers of:

(i) at least one layer substantially formed of an alloy represented by general formula (25) or (26) given below:

 $Ni_aFe_bCo_c$ (25)

 Ni_dFe_{100-d} (26)

where $0 < a \le 75 \text{ at}\%$, $0 < b \le 75 \text{ at}\%$,

 $0 < c \le 75 \text{ at}$ %, and a + b = 100; and

25 75 at% \leq d \leq 85 at%; and

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(ii) at least one layer formed of at least one element selected from the group consisting of Cr, V,

Ta, Nb, Sc, Ti, Mn, Cu, Zn, Ga, Ge, Zr, Hf, Y, Tc, Re, Ru, Rh, Ir, Pd, Pt, Ag, Au, B, Al, In, C, Si, Sn, Ca, Sr, Ba, O, N and F, and having a thickness falling within a range of between 0.03 nm and 1 nm.

5 21. A magnetoresistive device, comprising:

a magnetization pinned layer of which magnetization direction is substantially pinned to one direction;

a magnetization free layer of which magnetization

direction is changed in accordance with an external

magnetic field;

a nonmagnetic intermediate layer formed between the magnetization pinned layer and the magnetization free layer; and

- electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,
- wherein the magnetization pinned layer is substantially formed of an alloy represented by general formula (27) or (28) given below:

$$(Fe_aCo_bNi_C)_{100-x}M_x \tag{27}$$

$$(Fe_dCo_{100-d})_{100-x}M_x$$
 (28)

25 where $0 < a \le 75$ at%, $0 < b \le 75$ at%,

 $0 < c \le 75$ at%, and a + b = 100;

45 at% \leq d \leq 55 at%; and

M is at least one element selected from the group consisting of Cr, V, Ta, Nb, Sc, Ti, Mn, Cu, Zn, Ga, Ge, Zr, Hf, Y, Tc, Re, Ru, Rh, Ir, Pd, Pt, Ag, Au, B, Al, In, C, Si, Sn, Ca, Sr, Ba, O, N and F, and

0.1 at% $\leq x \leq 20$ at%,

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and wherein the magnetization free layer is substantially formed of an alloy represented by general formula (29) or (30) given below:

 $(Ni_e Fe_f Co_q)_{100-x} M_x$ (29)

 $(Ni_hFe_{100-h})_{100-x}M_x$ (30)

where 60 at% \leq e \leq 75 at%, 12.5 at% \leq f \leq 20 at%, 12.5 at% \leq g \leq 20 at%, and e + f + g = 100; 75 at% \leq h \leq 85 at%; and

M is at least one element selected from the group consisting of Cr, V, Ta, Nb, Sc, Ti, Mn, Cu, Zn, Ga, Ge, Zr, Hf, Y, Tc, Re, Ru, Rh, Ir, Pd, Pt, Ag, Au, B, Al, In, C, Si, Sn, Ca, Sr, Ba, O, N and F, and 0.1 at% $\leq x \leq 20$ at%.

- 22. A magnetoresistive device, comprising:
- a magnetization pinned layer of which
 magnetization direction is substantially pinned to one
 direction;

a magnetization free layer of which magnetization direction is changed in accordance with an external magnetic field;

a nonmagnetic intermediate layer formed between the magnetization pinned layer and the magnetization

free layer; and

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electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer,

wherein the magnetization pinned layer has a laminate structure comprising alternately laminated layers of:

(i) at least one layer substantially formed of an alloy represented by general formula (31) or (32) given below:

 $Fe_aCo_bNi_C$ (31)

 Fe_dCo_{100-d} (32)

15 where $0 < a \le 75$ at%, $0 < b \le 75$ at%, $0 < c \le 75$ at%, and a + b = 100;

45 at% \leq d \leq 55 at%; and

(ii) at least one layer formed of at least one element selected from the group consisting of Cr, V,
Ta, Nb, Sc, Ti, Mn, Cu, Zn, Ga, Ge, Zr, Hf, Y, Tc, Re, Ru, Rh, Ir, Pd, Pt, Ag, Au, B, Al, In, C, Si, Sn, Ca, Sr, Ba, O, N and F, and having a thickness falling within a range of between 0.03 nm and 1 nm,

and wherein the magnetization free layer has a laminate structure comprising alternately laminated layers of:

(i) at least one layer substantially formed of

an alloy represented by general formula (33) or (34) given below:

 $Ni_eFe_fCo_q$ (33)

 Ni_hFe_{100-h} (34)

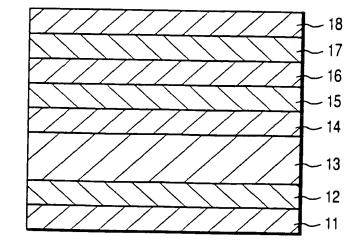
where 60 at% \leq e \leq 75 at%, 12.5 at% \leq f \leq 20 at%, 12.5 at% \leq g \leq 20 at%, and e + f + g = 100; 75 at% \leq h \leq 85 at%; and

- (ii) at least one layer formed of at least one element selected from the group consisting of Cr, V,
 Ta, Nb, Sc, Ti, Mn, Cu, Zn, Ga, Ge, Zr, Hf, Y, Tc, Re, Ru, Rh, Ir, Pd, Pt, Ag, Au, B, Al, In, C, Si, Sn, Ca, Sr, Ba, O, N and F, and having a thickness falling within a range of between 0.03 nm and 1 nm.
- 23. A magnetic head comprising the magneto-resistive device according to any of claims 1 to 22.
 - 24. A magnetic recording-reproducing apparatus, comprising a magnetic recording medium, and the magnetoresistive device according to any of claims 1 to 22.

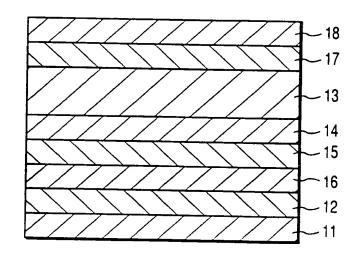
ABSTRACT OF THE DISCLOSURE

A magnetoresistive device includes a magnetization pinned layer, a magnetization free layer, a nonmagnetic intermediate layer formed between the magnetization 5 pinned layer and the magnetization free layer, and electrodes allowing a sense current to flow in a direction substantially perpendicular to the plane of the stack including the magnetization pinned layer, the nonmagnetic intermediate layer and the magnetization free layer. At least one of the magnetization pinned 10 layer and the magnetization free layer is substantially formed of a binary or ternary alloy represented by the formula $Fe_aCo_bNi_c$ (where a + b + c = 100 at%, and a \leq 75 at%, b \leq 75 at%, and c \leq 63 at%), or formed of 15 an alloy having a body-centered cubic crystal structure.

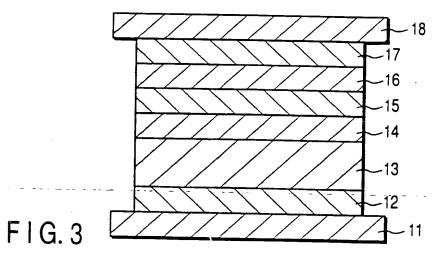




F I G. 1



F I G. 2





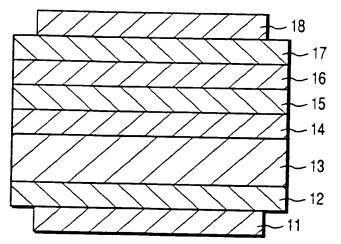
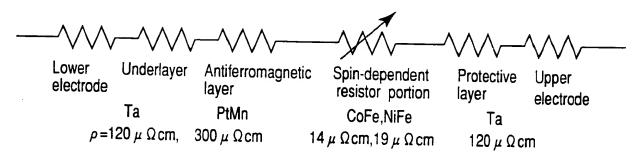


FIG. 4



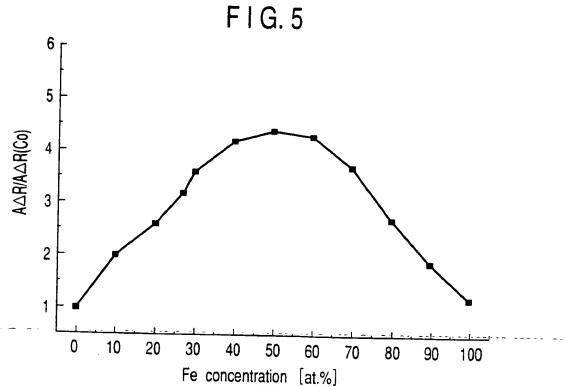


FIG.6



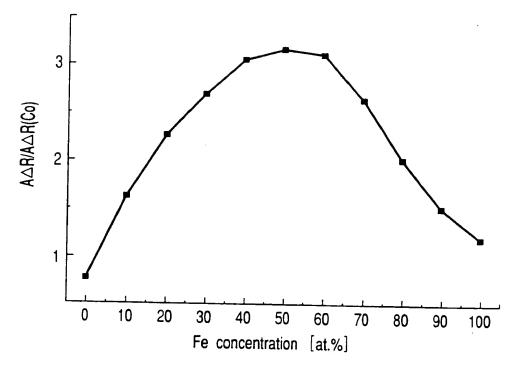
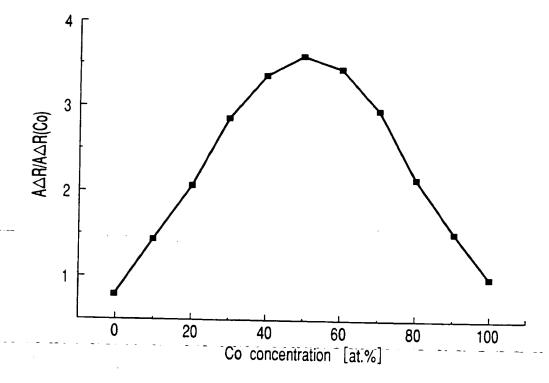
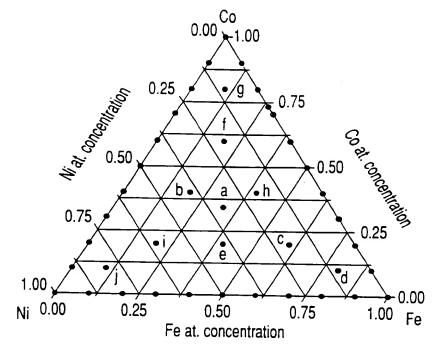


FIG.7



F1G.8





F1G.9

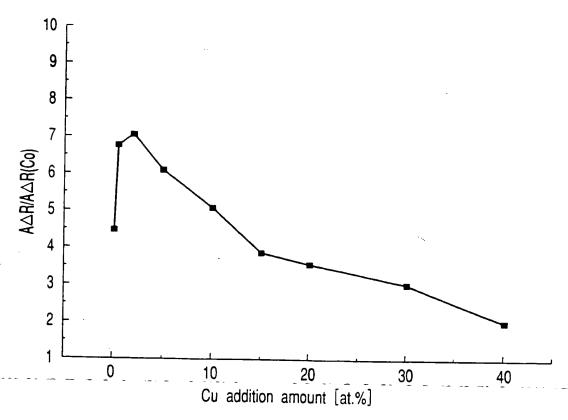
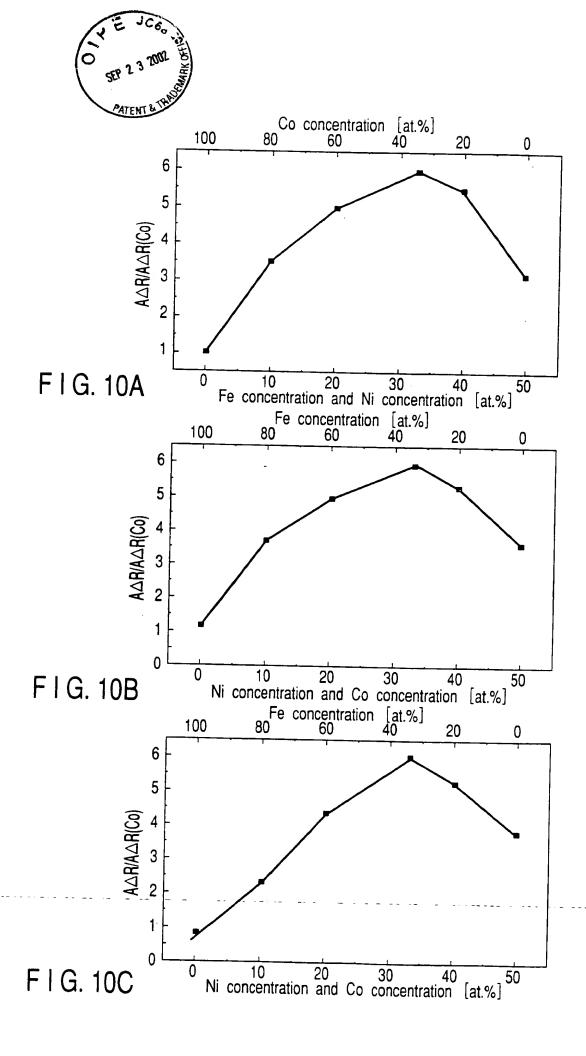
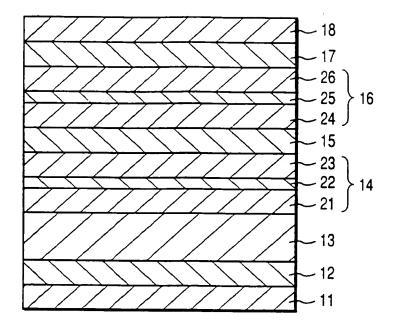


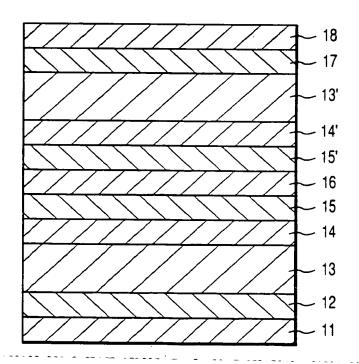
FIG. 11







F I G. 12



F I G. 13



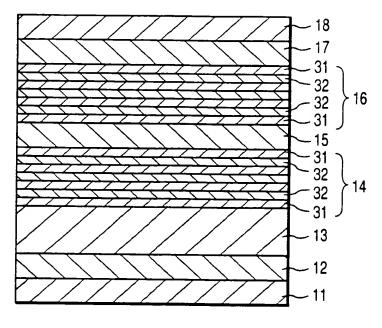
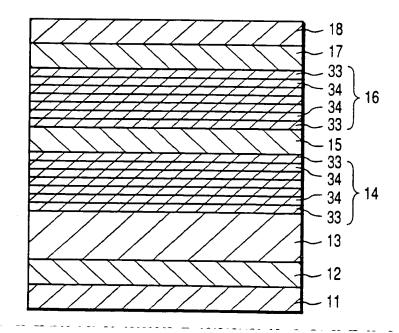
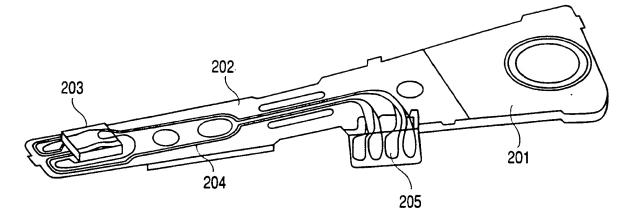


FIG. 14

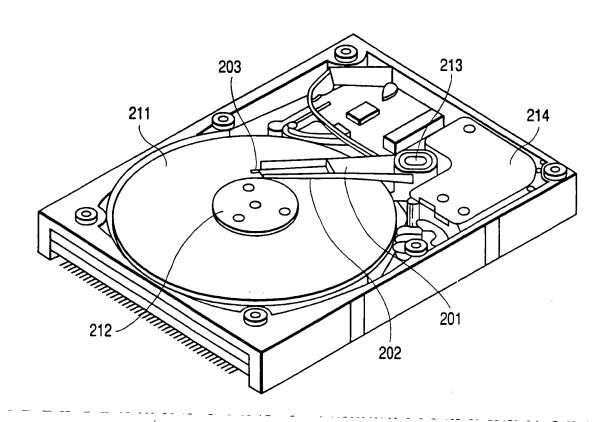


F | G. 15



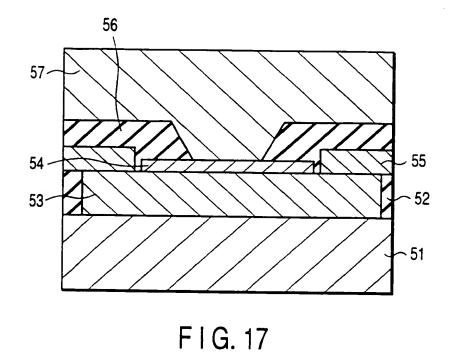


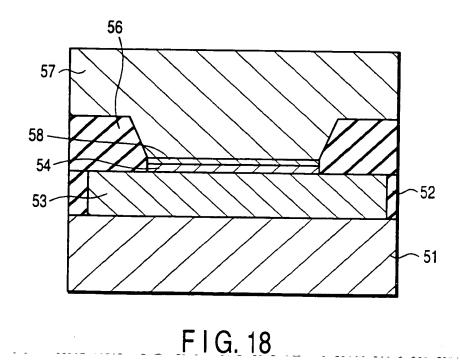
F I G. 16A



F I G. 16B







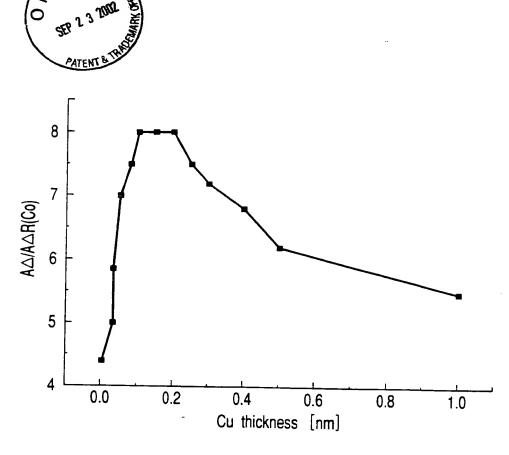


FIG. 19

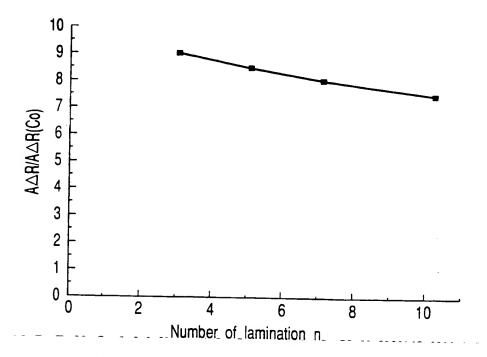
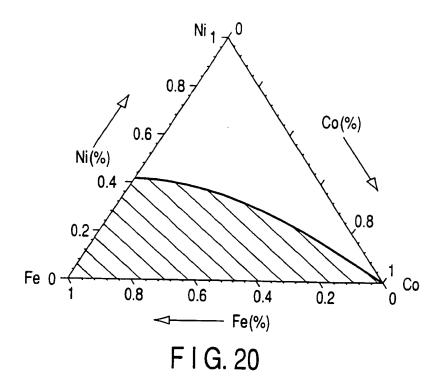
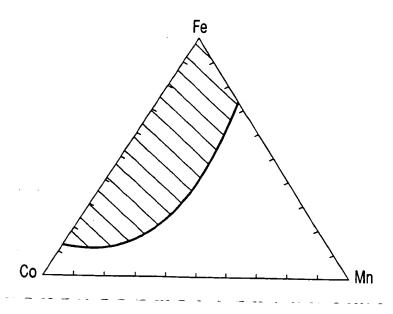


FIG. 22







F I G. 21

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